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A NEW SPECIES OF FOSSIL *NUTTALLIA* (MOLLUSCA: BIVALVIA) FROM THE PLIOCENE OF SONOMA COUNTY, CALIFORNIA

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Abstract: *Nuttallia jamesi*, new species, is described from strata assigned Pliocene age in the Sebastopol quadrangle, central Sonoma County, California. The species is similar to *N. nuttallii* (Conrad), late Miocene to Recent of California and Baja California, and to *N. olivacea* (Jay), Miocene to Recent of Japan, but differs from both in having an acuminate posterior end. The genus *Nuttallia* is restricted, in both Recent and fossil occurrence, to the north Pacific basin. It represents a temperately adapted branch of the predominantly tropical Sanguinolariinae.

Several years of field work by one of us (Guruswami-Naidu) at an exposure of soft sandstone in central Sonoma County, California, mapped as Merced Formation by Travis (1952), have resulted in a collection of more than forty marine invertebrate species (mostly mollusks) and numerous bird, fish, and mammal remains. Among the mollusks represented is a new species of the tellinacean bivalve genus *Nuttallia*, described herein. An account of the associated fauna and paleoecology will appear in a report now in preparation.

FAMILY PSAMMOBIIDAE FLEMING, 1828
Subfamily Sanguinolariinae Grant and Gale, 1931

Genus *Nuttallia* Dall, 1898

Nuttallia Dall, 1898: 58 [proposed as "section" of *Sanguinolaria* Lamarck, 1799]; Dall, 1900; Coan, 1973.

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Type species, by original designation, *Sanguinolaria nuttallii* Conrad, 1837; late Miocene to Recent, California and Baja California.

Dall (1900) characterized *Nuttallia* as follows: "Shell large, suborbicular, inequivalve, more or less twisted, the right valve slightly flatter, the posterior cardinal in the left valve obsolete; the pallial sinus narrower in front and somewhat detached from the pallial line." He gave this contrasting description of *Sanguinolaria, sensu stricto*: "Shell moderately large, thin, equivalve, short, rose-colored or white, with short, inconspicuous nymphs, two bifid cardinal teeth in each valve; pallial sinus deep, widest in front, confluent with the pallial line below,. the epidermis thin, dehiscent" (Dall, 1900). Living species of *Nuttallia* have a persistent, dark, generally glossy periostracum and a strong cardinal ligament borne on a projecting nymph. Fossil specimens with valves paired are relatively common. Coan's (1973) review of Recent northwest American Psammobiidae included a discussion of *Nuttallia nuttallii* (Conrad, 1837), type species of the genus and the only species known to be living in eastern Pacific waters. Kira (1953) reviewed the Recent Japanese species; Habe and Ito (1965) provide a later summary and synonymy.

Recent authors are almost evenly divided on whether to call *Nuttallia* a genus or a subgenus. It is often ranked as a subgenus of *Sanguinolaria* Lamarck, 1799 (type species, *Solen sanguinolentus* Gmelin, 1791), and occasionally as a subgenus of *Soletellina* Blainville, 1824 (type species, *Soletellina radiata* Blainville, = *Solen diphos* Linnaeus, 1771). (*Soletellina* is a junior synonym of *Hiatula* Modeer, 1793, since *Solen diphos* Linnaeus is the type species of the latter genus by subsequent designation [Stoliczka, 1870: 114]. A later designation [Winckworth, 1935] of *Mya truncata* Linnaeus, 1758, as type species of *Hiatula* is invalid.) As originally proposed by Grant and Gale (1931) the family Sanguinolariidae contained the genera *Gari* Schumacher, 1817, *Tagelus* Gray, 1847, and *Sanguinolaria* (including "section" *Nuttallia*), and was thus practically coextensive with Coan's (1973) usage of Psammobiidae Fleming, 1828. Keen (1969) reduced Sanguinolariidae to subfamily rank, including only the genus *Sanguinolaria* and under it seven subgenera, *Nuttallia* among them. In both morphology and distribution, *Nuttallia* seems sufficiently distinct from *Sanguinolaria* to receive generic rank, with its affinity expressed at the subfamilial level.

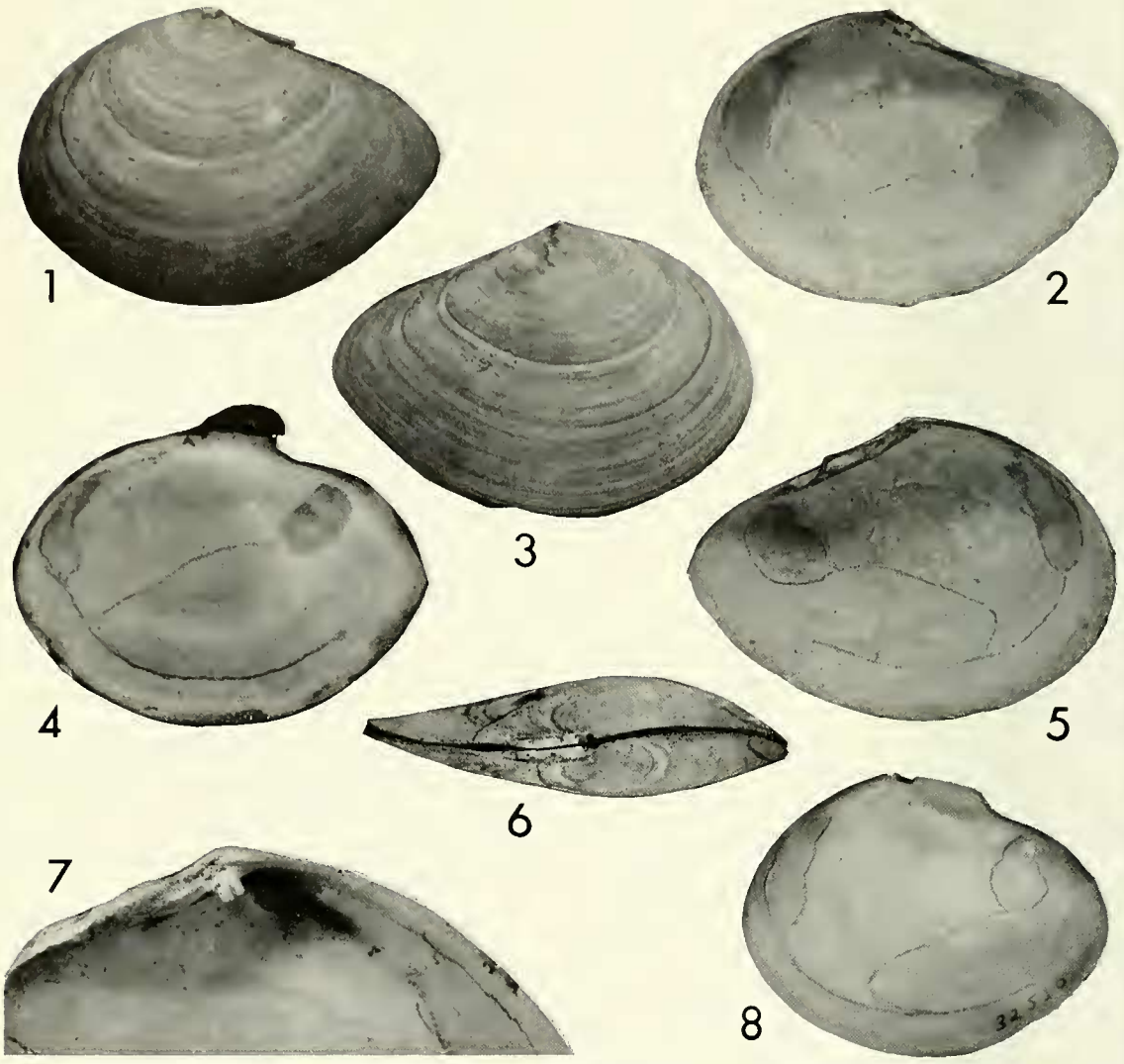
Typical *Sanguinolaria* species are tropical in distribution and occur in the [illegible] Pacific, and Panamic (eastern Pacific). In the Panamic province, the northernmost [illegible] for species of *Sanguinolaria, sensu stricto*, is the Gulf of California. That for *S. (Psammotella)* is San Ignacio Lagoon, Baja California (Keen, 1971), approximately 26° 45′ north latitude, near the 19° C February surface isotherm (Durham, 1950: fig. 2). Species of *Nuttallia* now occur in warm-temperate to cool waters in the north Pacific Ocean, and fossil occurrences are restricted to the margins of the north Pacific basin. Recent *N. nuttallii* ranges from Bodega Bay, California (38° 20′ N), to Magdalena Bay, Baja California (24° 40′ N) (Coan, 1973). Its range includes the southern portion of the Oregonian molluscan province, all of the Californian province, and the northern part of the Surian province, in the definitions of Valentine (1966). Valentine's Surian province is essentially equivalent to the portion of the west coast of Baja California regarded by Addicott (1966) as an area of provincial overlap, with Californian forms predominating in outer-coast biotopes and Panamic forms dominant in protected biotopes. By neither criterion is *Nuttallia nuttallii* a truly Panamic species, as one might infer from Coan's (1973: table 3) distributional tabulation. Kuroda and Habe (1952) cite the western Pacific species *Nuttallia petri* (Bartsch, 1929) as ranging from 43°–46° N, *Nuttallia olivacea* (Jay, 1857) from 30°–43° N, and *Nuttallia "nuttallii(?)"* [= *N. ezonis* Kuroda and Habe in Habe, 1955] from 39°–51° N. Both the western and eastern Pacific species which range into warm water–*N. nuttallii* and *N. olivacea*–are also found considerably farther north, in cool-temperate marine climates.

Phyletic separation of *Nuttallia* from *Sanguinolaria* dates from the Paleocene. The oldest known *Nuttallia, N. townsendensis* (Clark, 1925) from the late Eocene Quimper sandstone of Washington, occurs in a fauna of distinctly tropical aspect (Durham, 1950). The similar *N. uchigoensis* Kamada, 1962, from the upper Oligocene or lower Miocene Asagai Formation of Honshu, occurs in a molluscan assemblage suggestive of warm-temperate conditions and deposition offshore in moderate depths. Later Tertiary species show increasing adaptation to cooler conditions.

Nuttallia jamesi, new species

Figures 1–3, 5–7

Diagnosis: A small, thin-shelled species of *Nuttallia* with acuminate posterior end, narrow pallial sinus,



Figures 1–3, 5. Nuttallia jamesi, new species; external and internal views of holotype (CAS Department of Geology No. 54330). Length 53.4 mm. *Figure 4. Nuttallia nuttallii* (Conrad); internal view of right valve with ligament attached; Recent, southern California (CAS Department of Geology No. 54335). Length 62.2 mm. *Figure 6. Nuttallia jamesi*, new species; dorsal view of paratype (CAS Department of Geology No. 54331). Length 46.8 mm. *Figure 7. Nuttallia jamesi*, new species; detail of hinge of left valve of paratype (CAS Department of Geology No. 54332), nymph partly broken. *Figure 8. Nuttallia olivacea* (Jay); internal view of right valve; Recent, Iwai Mura, Chiba Prefecture, Japan (CAS Department of Geology No. 54334). Length 54.0 mm.

and hinge line sinuous in dorsal view, curving to the left posteriorly, to the right anteriorly.

Description: Shell small for the genus, thin; inequivalve, left valve more inflated than right valve; beaks situated at midline; anterior end of shell broad, evenly rounded, posterior end acuminate; surface of valves smooth except for incremental lines of varying strength. Hinge line shallowly sinuous in dorsal view, curving to the left posteriorly, to the right anteriorly. Right valve most inflated at about ⅓ of distance from beak to anterior end; compressed along both dorsal margins and along postero-ventral margin; with a radial angulation slightly below posterior dorsal margin; beak small, pointed; hinge plate narrow, with two diverging, oblique cardinal teeth, the posterior tooth larger and bifid; anterior dorsal margin convex; posterior dorsal margin concave, with a narrow escutcheon proximally, in which rises an elongate,

broad-topped nymph; pallial sinus narrow, deep, extending about ¼ of the distance anterior to midline, recurving before joining pallial line at an acute angle; muscle scars large; internal margin smooth. Left valve most inflated directly below beak; slightly compressed along posterior dorsal margin; with a blunt radial angulation running from beak to extreme posterior point of valve, and a shallow radial sulcus below this; beak elevated, small but prominent; hinge plate narrow, somewhat excavated, with a projecting, bifid anterior cardinal tooth (broken on holotype) and a small, nearly horizontal, laminar posterior cardinal tooth separated from the anterior tooth by a hollow; no lateral teeth present; posterior dorsal margin with a narrow escutcheon, in which rises a nymph, pairing with that of the right valve; pallial sinus and muscle scars like those of the right valve; internal margin smooth.

Dimensions: Holotype, length 53.4 mm; height 37.0 mm; diameter (both valves) 14.8 mm. Measured paratypes: (a) length 49.2 mm; height 36.6 mm; diameter 13.5 mm; (b) length 46.8 mm; height 33.9 mm; diameter 12.5 mm; (c) length 44.0 mm; height 32.9 mm; diameter 11.4 mm.

Type material: Holotype, right and left valves, No. 54330, Department of Geology, California Academy of Sciences. Paratypes, Nos. 54331–54333, same institution. Paratypes have been deposited in the following institutions: Department of Paleobiology, U. S. National Museum of Natural History; Museum of Paleontology, University of California, Berkeley; Department of Paleontology, Los Angeles County Museum of Natural History; Department of Geology, Stanford University; Institute of Geology and Paleontology, Tohoku University, Sendai, Japan.

Type locality: California Academy of Sciences Department of Geology locality No. 54164, roadcut in grayish-white, poorly indurated and highly fossiliferous sandstone on north side of River Road, 0.2 miles north of town of Trenton and 0.3 miles east of intersection of River Road and Trenton-Healdsburg Road, United States Geological Survey Sebastopol, California, quadrangle, 15 minute series (topographic), 1954 edition, Sonoma County, California (approximately 38° 29′ N, 122° 51′ W). On the geologic map of the Sebastopol quadrangle prepared by Travis (1952: pl. 1), the locality is at the fault contact between the Pliocene Merced Formation and "Jurassic" serpentine.

The species is named for Mr. James Nikas, student of west American paleontology, who first suggested that the taxon was undescribed.

DISCUSSION

Comparisons: The only *Nuttallia* previously recorded from Pliocene strata in western North America is *N. nuttallii* (Conrad, 1837). It has been reported in the Jacalitos, Etchegoin, and San Joaquin Formations on the west side of the San Joaquin Valley (Nomland, 1917; Weaver, Stewart and Richards, 1940 [1941]). Its earliest most occurrence, Recent or fossil, is in the middle Pliocene Falor Formation (University of California Museum of Paleontology invertebrate locality A 4234) of the Blue Lake quadrangle, Humboldt County, California. These two specimens were reported by Manning and Ogle (1950), as *Sanguinolaria nuttallii*, and appear to be typical of the species. *Nuttallia nuttallii* has a geologic range of late Miocene (Neroly) (Weaver, 1949) to Recent.

Nuttallia nuttallii (Fig. 4) is more inequivalve than *N. jamesi*, with the right valve nearly flat and the left valve strongly convex. The posterior end of *N. jamesi* is acutely pointed; that of *N. nuttallii* is broad, ending in an obtuse posterior angle. In dorsal view, the hinge line of *N. nuttallii* is less conspicuously sinuous than that of *N. jamesi*. The beaks of *Nuttallia nuttallii* are more anterior and the cardinal nymph is proportionally shorter and higher than on like-sized specimens of *N. jamesi*. The nymph of large specimens of *N. nuttallii* is low and elongate. In contrast to the relatively narrow pallial sinus of *N. jamesi*, the sinus of *N. nuttallii* is broad and trapezoidal and, although variable, is generally deeper, extending about half the distance anterior to the midline. The material at hand indicates that *N. jamesi* is a smaller species than *N. nuttallii*, which commonly reaches 90 mm and may reach 150 mm in length.

The nominal form *Sanguinolaria orcutti* Dall, 1921, described from the Pleistocene of San Quintin Bay, Baja California, and considered by Grant and Gale (1931) and Coan (1973) to be synonymous with *N. nuttallii*, is also larger than *N. jamesi*, with a broad, obtuse posterior end and trapezoidal pallial sinus. *Nuttallia toulai* (Hertlein and Jordan, 1927) from the Miocene of Baja California, is another large, suborbicular form, without the acuminate posterior end of *Nuttallia jamesi*.

Nuttallia olivacea (Jay, 1857) (Fig. 8), a common Recent species in Japan, also recorded as early as the Miocene, is in some respects the species most similar to *N. jamesi*. Both species are of similar size, with pallial sinuses of the same general shape. *Nuttallia olivacea*, however, has a bluntly angular posterior end, hinge line straight in dorsal view, a solid hinge plate, and both dorsal margins convex, while *N. jamesi* has a sharp posterior angle, hinge line sinuous in dorsal view, narrow hinge plate, and a concave posterior dorsal margin.

Other Asian Pliocene and Quaternary species are less similar. *Nuttallia ezonis* Kuroda and Habe in Habe, 1955, is morphologically very close to *N. nuttallii*, under which name it was reported by earlier workers. The record of "*Sanguinolaria* (*Nuttallia*) *nuttallii*" from upper Pliocene strata on the western coast of Kamchatka (Slodkewitsch, 1938) is probably referable to *N. ezonis*. *Nuttallia commoda* (Yokoyama, 1925), described from the Pliocene of Japan, is a large, subquadrate, equivalve species with concentric ridges crossing the shell. The Recent northwestern Pacific *Nuttallia petri* (Bartsch, 1929) is regarded by Habe and Ito (1965) as a synonym of *N. commoda*. *Nuttallia ochotica* (Slodkewitsch, 1936), an upper Pliocene species from the western coast of Kamchatka, also has low concentric ridges and, if not identical with *N. commoda*, is probably closely related to it.

Age: Travis (1952) considered the Merced Formation in the Sebastopol Quadrangle to be "probably upper Pliocene in age," based on both faunal criteria and local superposition with the middle to upper Pliocene Petaluma Formation. This age assignment of the Petaluma formation is based on remains of the horse, *Neohipparion gidleyi* Merriam, 1915, a species of Hemphillian age (Stirton, 1952). Berggren's (1971: table 52:40) Cenozoic radiometric time-scale places the Hemphillian stage in the interval 3.5–10 million years before present, late Miocene to mid-Pliocene in terms of the European series-epoch classification.

Fossils from Wilson Grove, 2 miles north of Trenton, were regarded by Dickerson (1922) as equivalent to the fauna of the type Merced Formation on the northern San Francisco Peninsula. Recent field work has shown several distinct faunal assemblages, indicating different environmental and depositional conditions, within the Sonoma County Merced Formation. The stratigraphic relationships of these and other published localities to the type locality of *Nuttallia jamesi* are obscured by lack of exposures and local faulting. A radiometric age of six million years has been obtained from tuff interbedded in Merced Formation sandstones in the Sebastopol quadrangle (G. H. Curtis, personal communication). We have not determined the stratigraphic relationship of this tuff to the type locality of *N. jamesi*.

Approximately one-third of the molluscan taxa at CAS locality 54164 are extinct. *Protothaca staleyi* (Gabb, 1866), *Nucella trancosana* (Arnold, 1908), *Nassarius* (*Caesia*) *grammatus* (Dall, 1917), *Nassarius* (*Demondia*) *californianus* (Conrad, 1856), *Ophiodermella graciosana* (Arnold, 1907), and *Megasurcula remondii* (Gabb, 1866) are among the extinct species widespread in strata traditionally classified as Pliocene in the west American provincial sequence. The presence of *Nassarius* (*Caesia*) *grammatus* and the absence of *N.* (*C.*) *moranianus* (Martin, 1914) would seem to exclude an uppermost Pliocene or early Pleistocene age for this fauna (cf. Addicott, 1965: B6–B8, fig. 1). This line of evidence places CAS locality 54164 stratigraphically below all or part of the Merced section at Bolinas, Marin County, California, the type locality of *Nassarius moranianus*. The presence in the fauna of an undescribed echinoid of the genus *Scutellaster* may afford more precise placement within the west coast faunal sequence (J. W. Durham, pers. comm.). We conclude that the assemblage is Pliocene in the traditional terminology of west coast paleontologists, but possibly should be called late Miocene in reference to the European series-epoch classification.

Paleoecology: The molluscan assemblage at the Trenton locality suggests deposition on a silty sand bottom in 15 to 40 meters depth, with several elements transported downslope from rocky and sandy intertidal and shallow subtidal areas probably less than a mile distant. As will be discussed in a forthcoming paper, several features of the fauna support analogy with present-day conditions at the southern end of Monterey Bay, California. Paired, intact valves (seven pairs in the type lot) of the rather thin-shelled *Nuttallia jamesi* might be interpreted as suggesting burial in place, rather than transport into the assemblage. Much of the fossil material from locality 54164, however, consists of indeterminable pelecypod fragments; thus the type lot represents an unknown fraction of the total *Nuttallia* component of the faunule.

Recent *Nuttallia nuttallii* usually lives intertidally in protected bays, particularly in entrance channels washed by fast-moving tides, buried in loose sand or mixed sand and gravel (Fitch, 1953). It is less common on the open coast, where it occurs in sand below wave-base. The greatest depth from which the species is reported is 10 meters (Coan, 1973). The Japanese species, *Nuttallia olivacea*, has been reported from sandy and muddy bottoms, intertidally to 10 m (Kuroda, Habe, and Oyama, 1971). *Nuttallia ezonis* was cited by Habe (1964) as occurring on fine sand

bottoms from low tide level to "several" meters depth.

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TWO NEW SPECIES OF LAND SNAILS FROM THE PINALENO MOUNTAINS, ARIZONA

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Abstract: Two new species of land snails are described from the Pinaleno Mountains in southeastern Arizona.

The Pinaleno Mountains, sometimes called the Graham Mountains, lie in line with the Chiricahua system in southeastern Arizona and are separated from the northern end of the Dos Cabezas Mountains by a wide mesa. The Pinalenos have long been neglected by malacologists. A brief account is given (Pilsbry and Ferriss, Proc. Acad. Nat. Sci. Philadelphia, for 1918: 282–334, 1919) of a collecting trip made by Ferriss, 14 October 1913, "Besides *Sonorella* and *Oreohelix*, *Vitrina alaskana* was abundant and two young Vallonias were found." Pilsbry and Ferriss described *Sonorella grahamensis* from this material but there was no further mention of the *Oreohelix*.

On 21 April 1954, M. L. Walton and one of us (Gregg) visited the Pinaleno Mountains. Leaving Safford on US highway 666, we traveled south seven miles, then turned west on the "Swift Trail," now a well-maintained mountain road. We continued about 20 miles which took us to near 9000 feet altitude. Stopping now and then to look for snails, we found *Sonorella* and *Oreohelix* and in the same microhabitat, *Microphysula ingersolli meridionalis* (Pilsbry and Ferriss), *Retinella indentata paucilirata* (Morelet), *Zonitoides arboreus* (Say), *Striatura meridionalis* (Pilsbry and Ferriss), *Deroceras* sp., *Discus*

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Figure 1. Sonorella imitator, new species. Genitalia drawing made from projection of stained whole mount: ag, albumin gland; ec, epiphallic caecum; ep, epiphallus; go, genital orifice; hd, hermaphroditic duct; ot, ovotestes; ov, oviduct; pe, penis; pr, penial retractor; ps, penial sheath; pt, prostate; sd, spermathecal duct; sp, spermatheca; ta, talon; ut, uterus; va, vagina; vd, vas deferens; ve, verge.